Signals and Circuits

ENGR 35500

Mesh Analysis

Chapter 3: 3-2 (Mesh-Current Method) pp. 100-105; 3-5 (Thevenin and Norton Equivalent circuits) pp. 113-119;

Ulaby, Fawwaz T., and Maharbiz, Michael M., *Circuits*, 2nd Edition, National Technology and Science Press, 2013.

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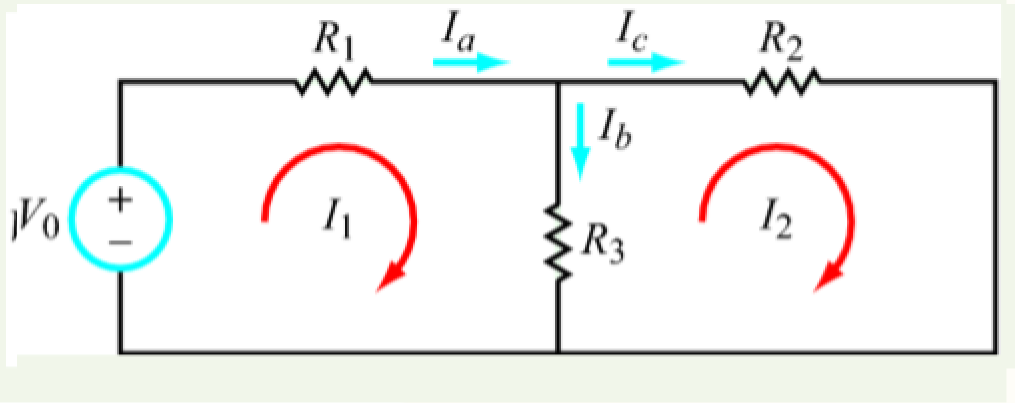
Mesh Analysis

- Sometimes also called Loop analysis;
- Based on KVL;
- Based on distinguishing types of loops.

Mesh Analysis



Step 1: Identify all the meshes and assign each of them an unknown mesh current (Usually clockwise).

Step 2: KVL+Ohm's law

$$-V_0 + I_1R_1 + (I_1 - I_2)R_3 = 0 \qquad (Mesh\ 1)$$

$$(I_2 - I_1)R_3 + I_2R_2 = 0 \qquad (Mesh\ 2)$$

Step 3: Solve the simultaneous equations to get the mesh current.

Step 4: Transfer mesh current to actual current

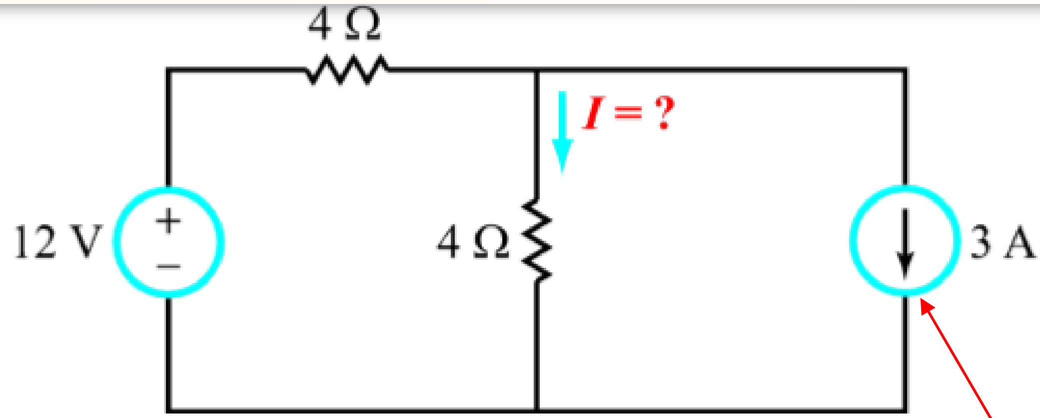
$$I_a = I_1$$

$$I_c = I_2$$

$$I_b = I_1 - I_2$$

Mesh Analysis

Practice



Step 1: Identify all the meshes and assign each of them an unknown mesh current (Usually clockwise).

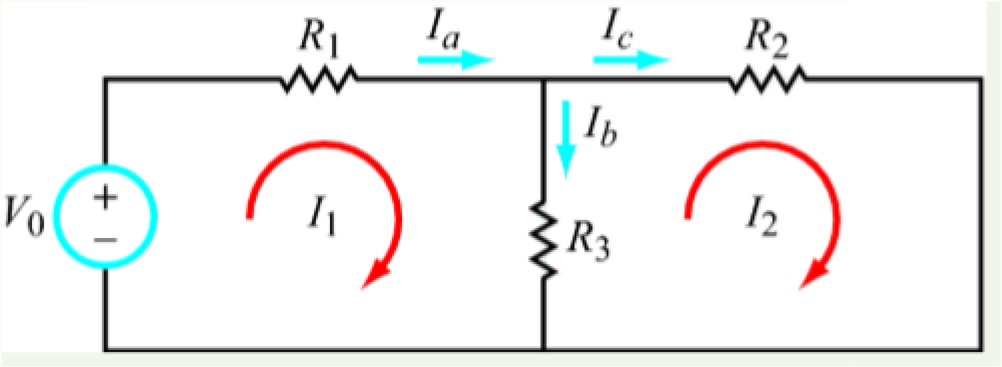
Step 2: KVL+Ohm's law

Step 3: Solve the simultaneous equations to get the mesh current.

Step 4: Transfer mesh current to actual current

Note: sometimes some mesh current can be expressed directly by some current source

Original Method VS Nodal Method VS Mesh Method



Original method (KL)

1. Labels
2. Distinguish loops
3. Creat current equations using KVL+Ohm's law
4. KCL
5. Simultaneous solution of equations

Nodal Method

0. Supernodes and quasi-super node

1. Identify extraordinary nodes, label (n_{ex} - 1) extraordinary nodes and one ground node.
2. At (n_{ex} - 1) extraordinary nodes, label current as leaving the nodes.
3. At each (n_{ex} - 1) extraordinary node, appy KCL
4. Try to substitute the currents with the terms of voltages
5. Simultaneous solution of equations

Mesh method

0. ?

1. Identify all the meshes and assign each of them an unknown mesh current (Usually clockwise).
2. KVL+Ohm's law
3. Solve the simultaneous equations to get the mesh current.
4. Transfer mesh current to actual current

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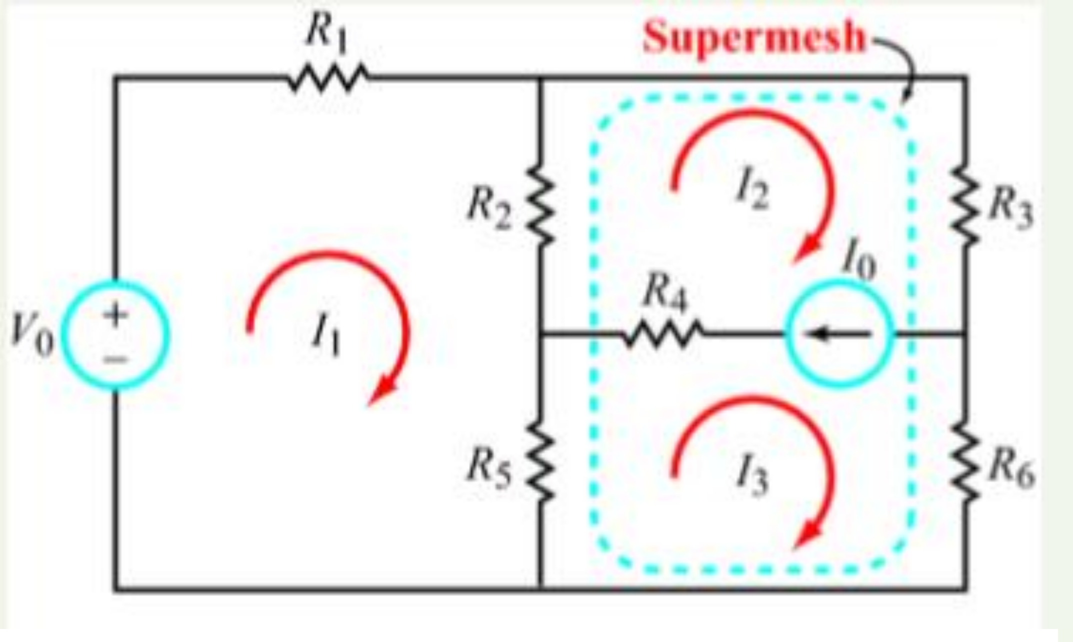
Mesh analysis

Supermesh



Two adjoining meshes that share a current source constitute a supermesh. The current source may be of the independent or dependent type, and it may include a resistor in series with it.

Mesh method

0. supermesh, mesh current directly from current
1. Identify all the meshes and assign each of them an unknown mesh current (Usually clockwise).
2. KVL+Ohm's law
3. Solve the simultaneous equations to get the mesh current.
4. Transfer mesh current to actual current

$$-V_0 + R_1 I_1 + (I_1 - I_2)R_2 + (I_1 - I_3)R_5 = 0 \qquad (Mesh\ 1)$$

$$(I_3 - I_1)R_5 + (I_2 - I_1)R_2 + I_2 R_3 + I_3 R_6 = 0 \quad (Super\ Mesh)$$

$$I_0 = I_2 - I_3 \ \ (auxiliary\ eq.)$$

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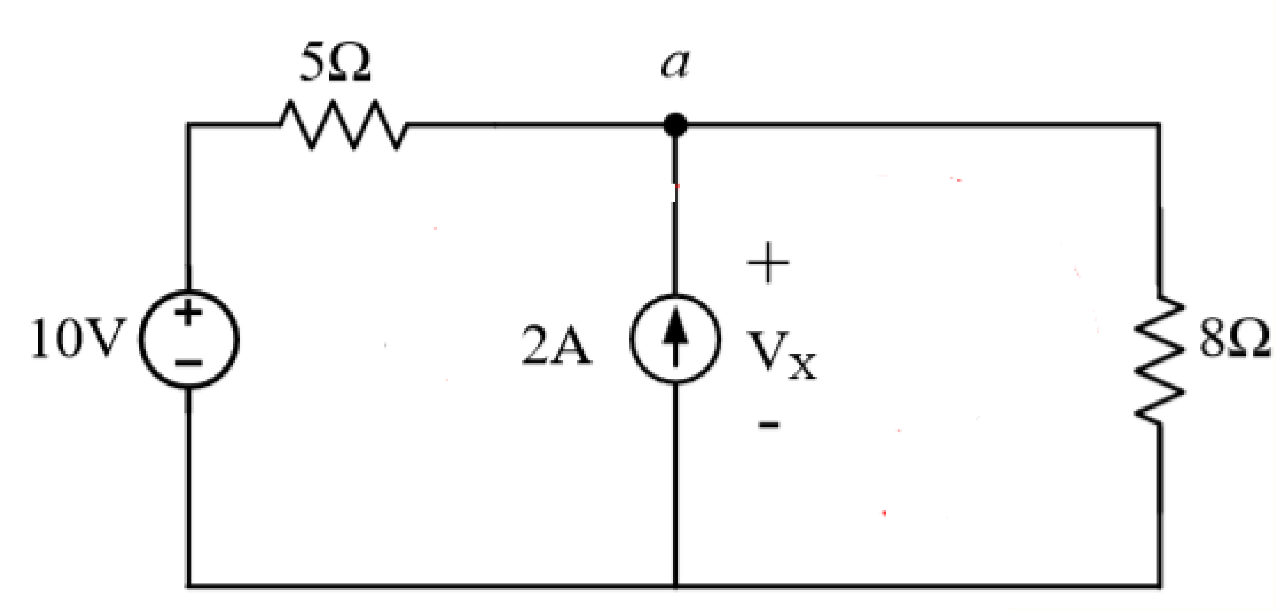
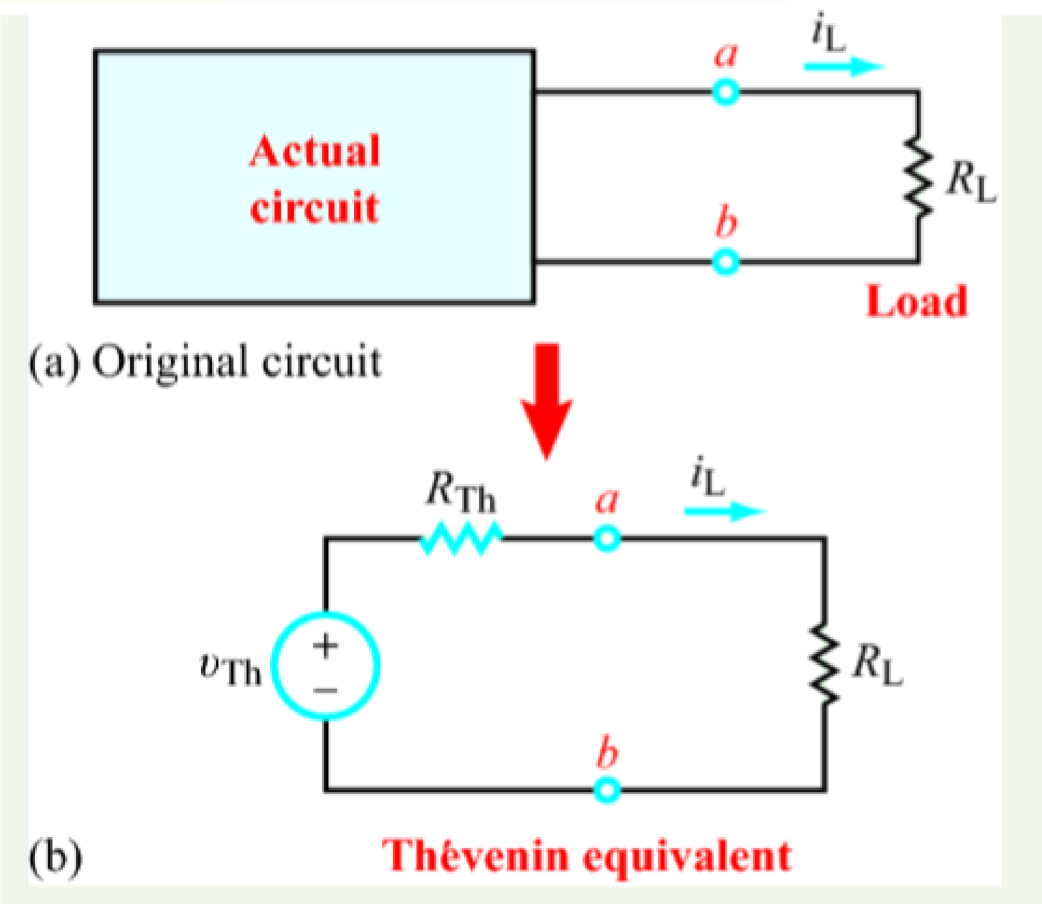
Mesh analysis

Determine *Vx*



Thevenin's and Norton's Theorems

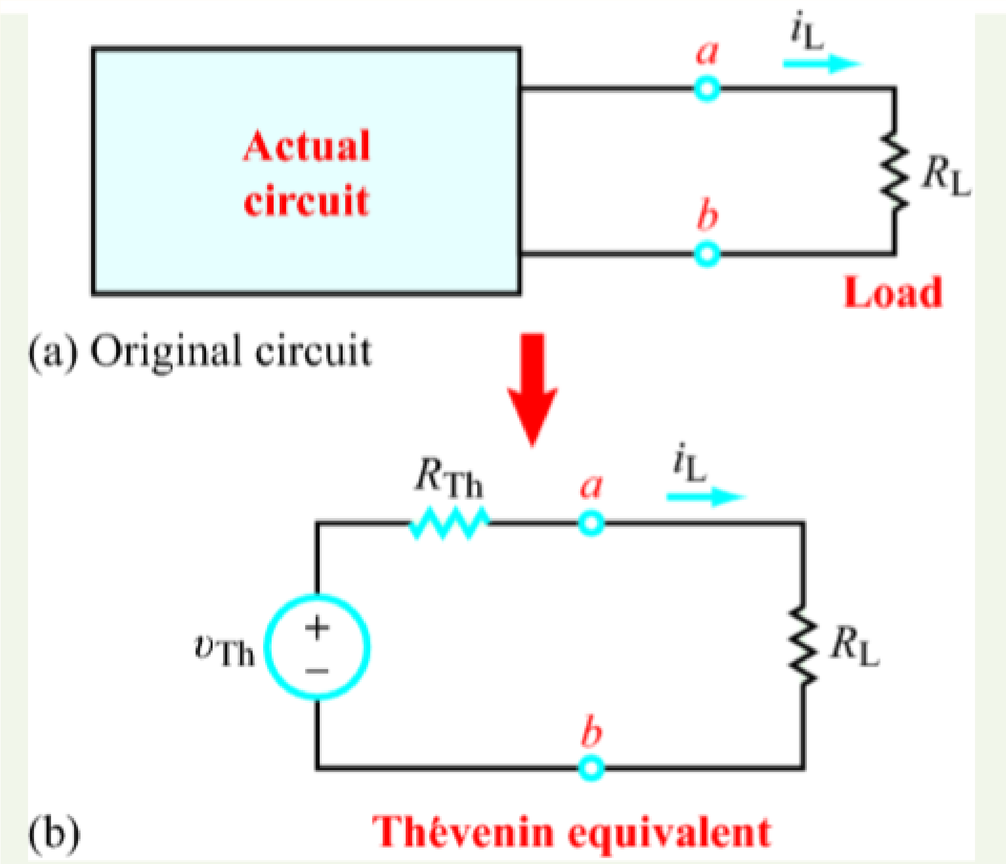


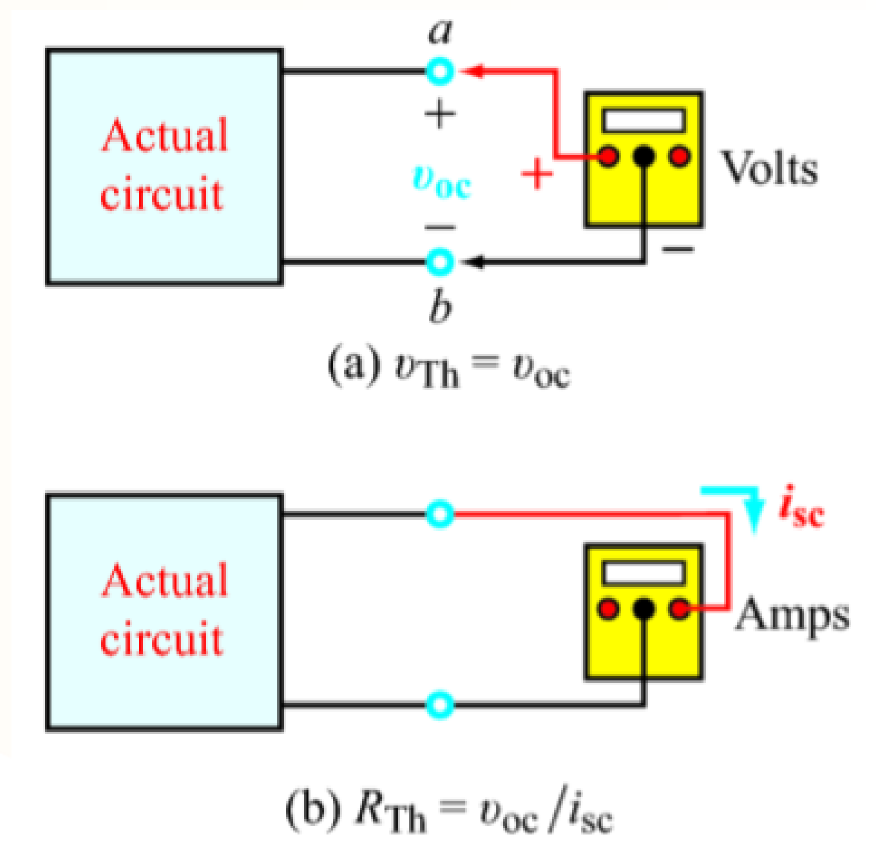
Thevenin's Theorem

A **linear** circuit can be represented at its output terminals by an equivalent circuit consisting of a series combination of a voltage source V_{Th} and a resistors R_{Th}.

Thevenin’s and Norton’s Theorems

Open-circuit/short-circuit method



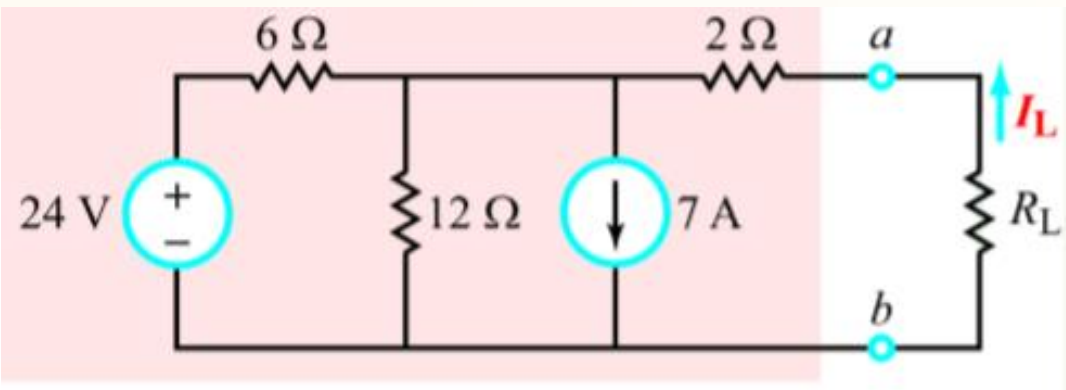


The Thevenin voltage V_{Th} is obtained by removing the load R_L (replacing it with an open circuit), and then measuring or computing the open-circuit voltage at the same terminals. The short-circuit current i_{sc} is obtained by replacing the load with a short circuit and then measuring or computing the short-circuit current flowing the through it.

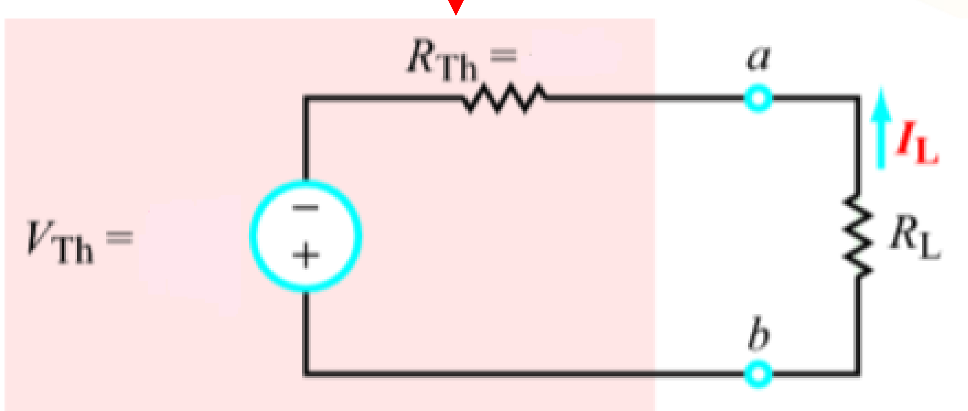
Thevenin's and Norton's Theorems

Open-circuit/short-circuit method

Find R_L could make I_L as 0.5 A

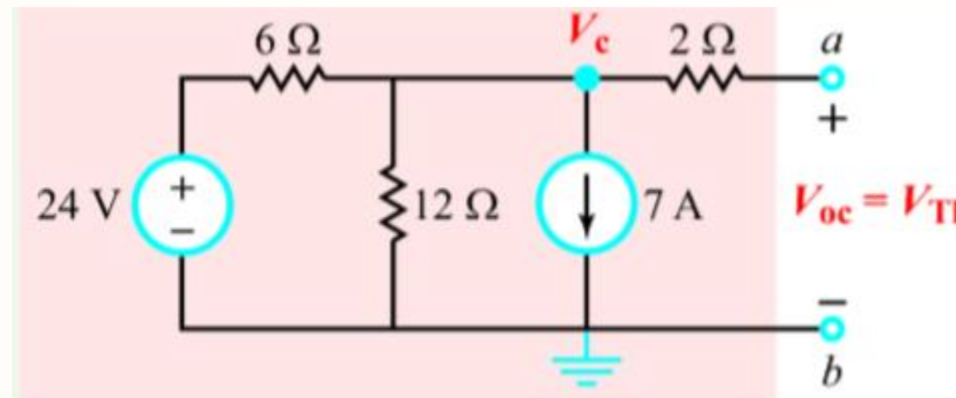


Original circuit



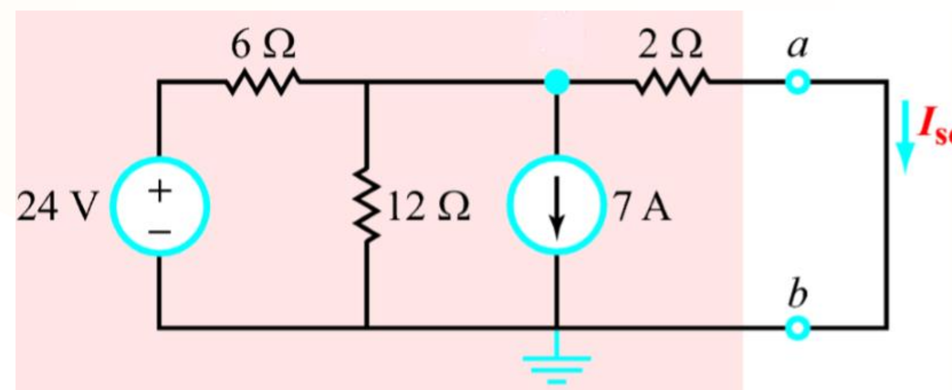
Thévenin equivalent circuit

Step 1:



Replacing R_L with open circuit

Step 2:



Replacing R_L with short circuit

$$R_{Th} = V_{Th}/I_{sc}$$

Step 3:

$$I_L = V_{Th}/(R_L + R_{Th})$$

Note: This method is applicable to any circuit with at least one independent source, regardless of whether or not it contains dependent sources.

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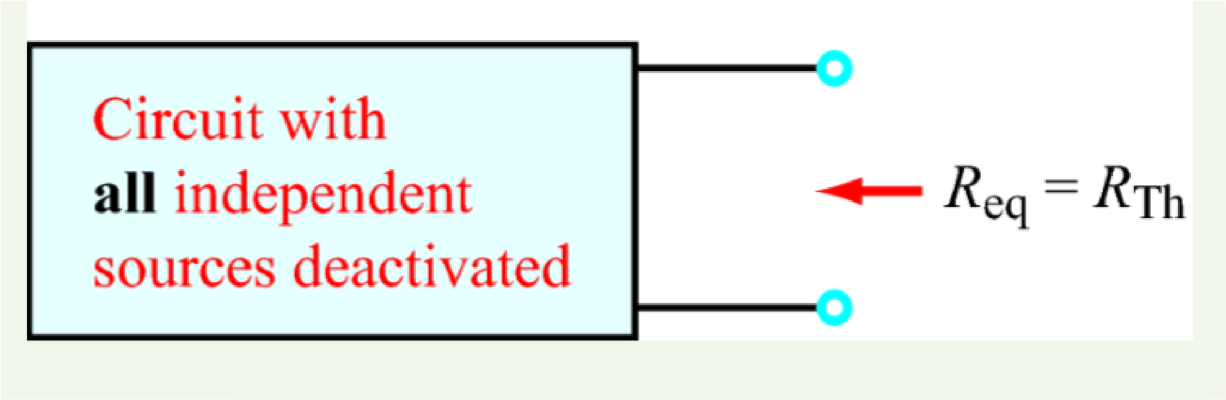
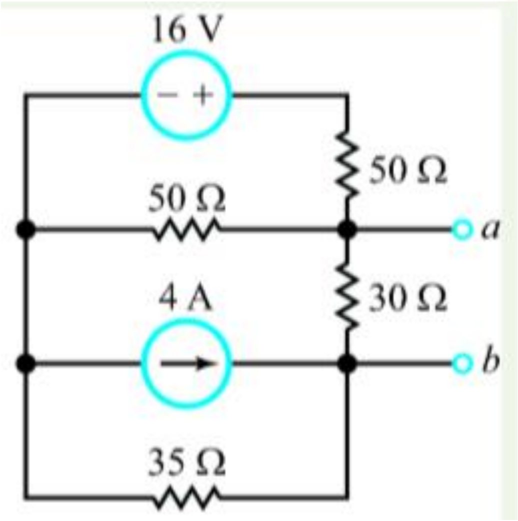
Thevenin's and Norton's Theorems

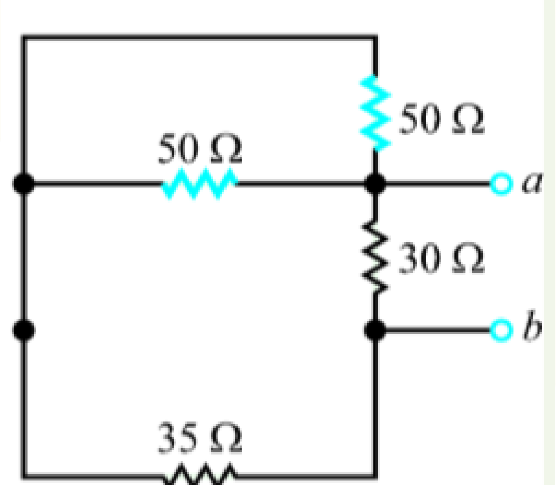
Equivalent-resistant method for R_{Th}



E.g.



Original circuit



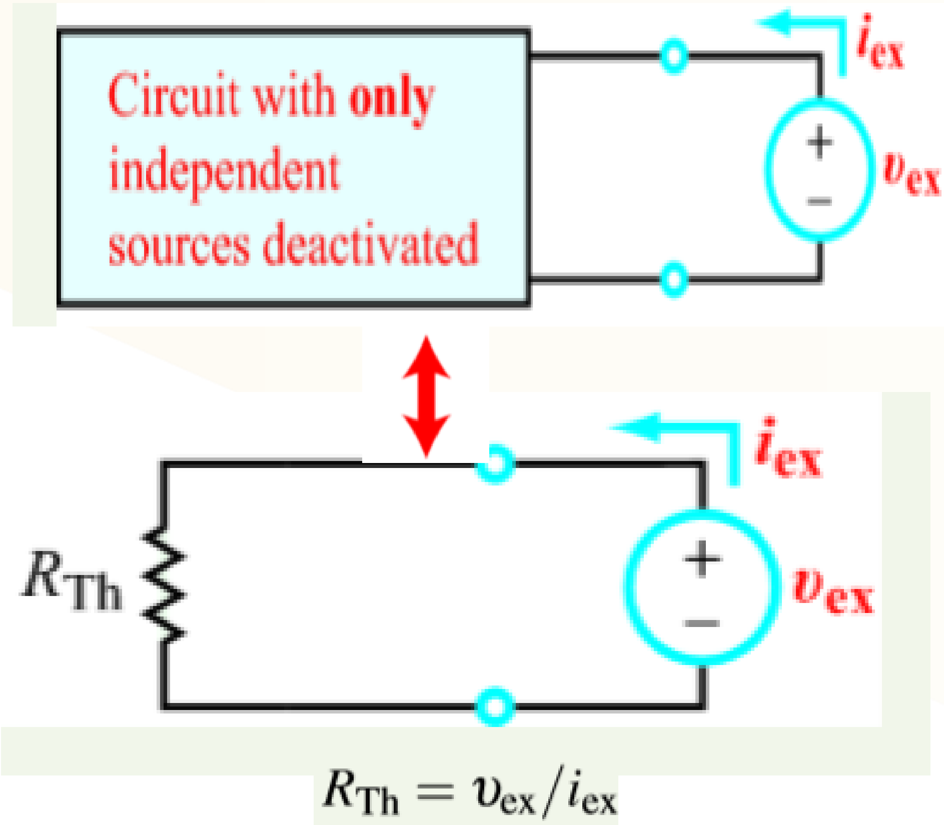
After deactivating sources

1. Replace voltage sources with short circuits
2. Replace current sources with open circuits

Note: This method is not applicable to circuit with that contain dependent sources.

Thevenin's and Norton's Theorems

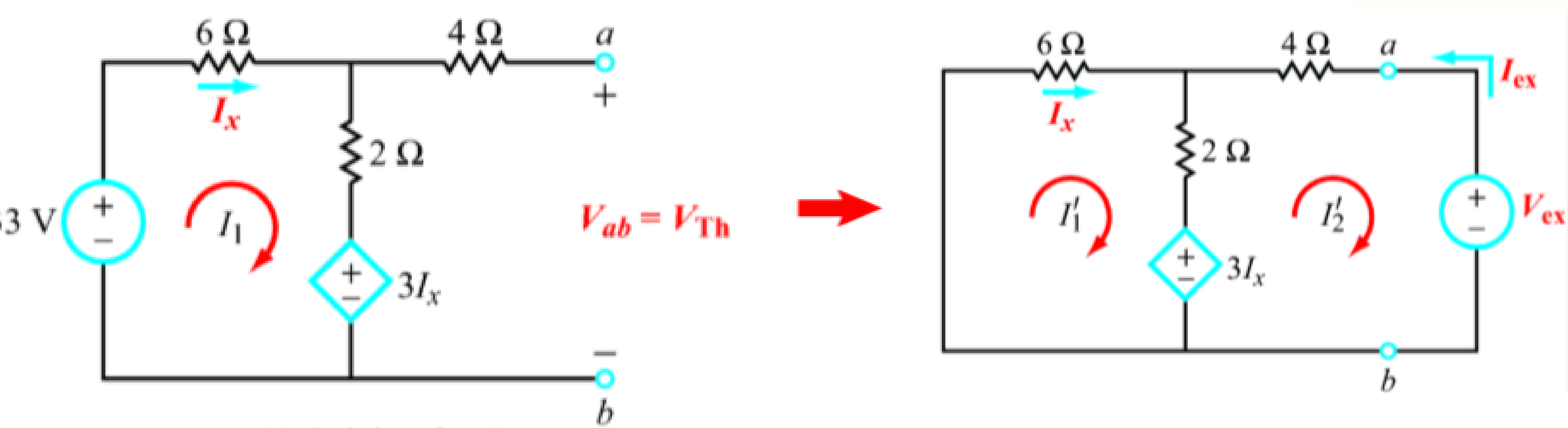
External-source method for R_{Th}



1. Replace independent voltage sources with short circuits
2. Replace independent current sources with open circuits
3. Left the dependent sources alone
4. Add an external voltage source v_{ex}, and calculate v_{ex} and i_{ex}

Note: This method is applicable to circuit with that contain dependent sources.

E. g.



calculate v_{ex} and i_{ex}

$R_{Th} = v_{ex}/i_{ex}$

Thevenin and Norton Equivalency